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TRANSMITTAL OF APPEAL BRIEF	Docket No. M4065.0315/P315

In re Application of: Er-Xuan Ping, et al.

Application No.	Filing Date	Examiner	Group Art Unit
09/651,998	August 31, 2000	H. Tsai	2812

Invention: METHOD AND STRUCTURE FOR REDUCING LEAKAGE CURRENT IN CAPACITORS

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TO THE COMMISSIONER OF PATENTS:

Transmitted herewith in triplicate is the Appeal Brief in this application, pursuant to the Notice of Appeal filed: June 13, 2002.

Pursuant to the favorable Decision on the Petition to Revive the Unintentionally Abandoned Application, the due date for filing this Appeal Brief has been set to **two months** from the date of mailing of the Decision, which was **August 23, 2002**.

The fee for filing this Appeal Brief is 320.00.

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Dated: October 23, 2002

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Docket No.: M4065.0315/P315
(PATENT)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of:
Er-Xuan Ping, et al.

Application No.: 09/651,998

Group Art Unit: 2812

Filed: August 31, 2000

Examiner: H. Tsai

For: METHOD AND STRUCTURE FOR REDUCING LEAKAGE CURRENT IN CAPACITORS

APPELLANT'S BRIEF

Attention: Board of Patent Appeals and Interferences
Commissioner for Patents
Washington, DC 20231

Dear Sir:

This brief is in furtherance of the Notice of Appeal, filed in this case on June 13, 2002.

The fee required under § 1.17(f) is to be paid in the manner indicated in the accompanying TRANSMITTAL OF APPEAL BRIEF.

This brief is transmitted in triplicate.

I. REAL PARTY IN INTEREST

The real party in interest for this appeal is Micron Technology, Inc., the assignee of this application.

II. RELATED APPEALS AND INTERFERENCES

There are no other appeals or interferences which will directly affect or be directly affected by or have a bearing on the Board's decision in this appeal.

III. STATUS OF CLAIMS

Claims 1-95 are pending, with claims 60-95 being withdrawn from consideration. Claims 1-59 are on appeal.

IV. STATUS OF AMENDMENTS

The Amendment Under 37 C.F.R. § 1.116 filed on March 27, 2002 was not entered.

The Amendment filed on April 30, 2002 and resubmitted on June 13, 2002 was not entered.

Accordingly, the claims enclosed herein as Appendix A do not incorporate either of these amendments.

V. SUMMARY OF INVENTION

The invention provides a method of forming a capacitor in a semiconductor device in which a first layer of conductive material is first formed, a second layer of a dielectric is formed over the first layer, the second layer is then contacted with hydrogen, oxygen and nitrous oxide gases to form an oxidation layer over the second layer, and a third layer of conductive material is then formed over the second layer. Specifically, the oxidation layer is formed by adding an oxygen containing gaseous material (e.g, nitrous oxide) to a mixture of oxygen and hydrogen gases, and then contacting the capacitor dielectric with the gaseous mixture. Preferably, the flow rate of the nitrous oxide gas is increased during oxidation while the flow rate of the hydrogen and oxygen gases are maintained substantially constant. The gas ratio of nitrous oxide to hydrogen and oxygen can be varied by either changing the nitrous oxide gas flow rate while keep the hydrogen and oxygen flow rates constant, or vice versa. The resulting structure exhibits a lowered current leakage with little

loss of capacitance when compared with similar capacitor structures in which the dielectric is built with a conventional hydrogen and oxygen treatment which forms an oxidation layer on the dielectric. The invention is more completely defined n the appended claims.

VI. ISSUES

Whether claims 1-59 are rendered obvious by United States Patent Number 6,096,592 to Cho or United States Patent Number 5,254,505 to Kamiyama, in view of United States Patent Number 6,114,258 to Miner et al. and United States Patent Number 5,624,865 to Shuegraf et al.

VII. GROUPING OF CLAIMS

For purposes of this appeal brief only, and without conceding the teachings of any prior art reference, the claims have been grouped as indicated below:

Claims 1, 9-12, 40-42 and 50 stand or fall together. Each of claims 2, 3, 4 and 5 each stand or fall separately. Claims 6-8, 15-34, 45-47, 49, 51-55, and 59 stand or fall together. Each of claims 13 and 14 stands or falls separately. Each of claims 35 and 36 stands or falls separately. Claims 37-38 stand or fall together. Each of claims 39, 43, 44 and 48 stands or falls separately. Each of claims 56, 57, and 58 stands or falls separately.

In Section VIII below, Applicant has included arguments supporting the separate patentability of each claim group as required by M.P.E.P. § 1206.

VIII. ARGUMENTS

A. THE CITED REFERENCES, WHETHER CONSIDERED SEPARATELY OR IN COMBINATION, FAIL TO TEACH OR SUGGEST THE CLAIMED INVENTION.

In the final Office Action dated November 30, 2001, claims 1-59 were finally rejected as being unpatentable over U.S. Patent No. 6,096,592 to Cho or U.S. Patent No. 5,254,505 to Kamiyama, in view of U.S. Patent No. 6,114,258 to Miner et al. and U.S. Patent No. 5,624,865 to Schuegraf et al. Appellants respectfully submit that this rejection is improper for each of the reasons discussed below.

1. The References Provide No Motivation To Contact the Dielectric Layer with H_2Gas, O_2 Gas, And Nitrous Oxide Gas as Recited in Independent Claims 1 and 40.

Independent claims 1 and 40 are directed to a method of forming a capacitor structure formed in a semiconductor device, and each includes the act of contacting a dielectric layer "with hydrogen, oxygen, and nitrous oxide gases so as to form an oxidation layer over" the dielectric layer. As discussed throughout the specification and demonstrated in the experimental data provided in Tables 1 and 2 on pages 13-14 thereof, there is a significant and unexpected reduction in capacitor leakage current when the capacitor dielectric is oxidized with the claimed gas mixture compared with the leakage current obtained when the dielectric layer in the capacitor was oxidized by the mixture of hydrogen and oxygen gases only (without nitrous oxide gas). Specifically, the samples of Group I in Tables 1 and 2 were oxidized using only hydrogen and oxygen gases, while the samples in Groups 2-4 were oxidized using a mixture of hydrogen, oxygen, and nitrous oxide. Each Group included samples having dielectric layers which were 47 Angstroms thick and also samples having dielectric layers which were 59 Angstroms thick. Table 2 shows that the leakage current through the dielectric layers of the samples of Groups 2-4 were greatly reduced from the leakage current through the dielectric layers of the samples of Group 1. For example, for the samples having a dielectric layer thickness of 47

Angstroms, the amount of leakage current obtained upon applying –1.6 V to the capacitors of Groups 1-4 are –4.46E-08 A/cm^2, -2.05E-08 A/cm^2, -1.88E-08 A/cm^2, and –1.64E-08 A/cm^2, respectively. This data indicates that the leakage current observed in the samples of Groups 2-4 equate to 46%, 42%, and 37%, respectively, of the leakage current observed in the samples of Group 1. As mentioned on page 10, lines 16-24 in the specification, it is not known exactly why the use of the claimed mixture produces such superior results, but a marked improvement in leakage current suppression does clearly occur.

None of Cho, Kamyiama, Miner or Schuegraf, whether considered alone or in combination, teaches the claimed mixture of hydrogen, oxygen, and nitrous oxide gases to oxidize a dielectric layer of a capacitor. Furthermore, one of ordinary skill in the art would not have been motivated by these references to use the claimed mixture of gases to oxidize a dielectric layer, because none of the references recognizes the unexpectedly superior results of using the claimed mixture.

Cho teaches processing the surface of a dielectric layer 48 using a plasma (Cho, col. 4, lns. 33-42). A plasma is a distinct phase of matter which is composed of ions and electrons, not molecules, as are the hydrogen, oxygen and nitrous oxide gases recited in Appellants' claims. *See, e.g.*, Paul A Tipler, Modern Physics, p. 312, (Worth Publ. Inc. 1978) (copy attached hereto as Appendix B). For example, a hydrogen plasma contains H+ ions and electrons, which is very different from hydrogen gas, which consists only of H_2 molecules. Thus, Cho fails to teach or suggest contacting the dielectric layer with any of a hydrogen gas (H_2), oxygen gas (O_2), or nitrous oxide gas (N_2O), much less a combination of the three as recited in Appellants' claims.

Moreover, the source gas for the plasma used in Cho is made from a source gas which may be a mixture comprising "one compound selected from the group consisting of H_2, NH_3, and PH_3 with at least one compound selected from the group consisting of Ar, N_2, O_2, and N_2) (col. 4, lns. 52-57). There are 45 different combinations of source gases

which may be obtained from this list. There is no recognition in Cho of the superior results obtained by oxidizing a capacitor dielectric using the specific combination of H_2, O_2 and N_2O, nor is there any other motivation to select the specific combination of gases recited in claims 1 and 40 in the present application.

The final rejection contends that Kamiyama discloses a first conductive layer, a dielectric layer formed over the first conductive layer, an oxide layer formed over the dielectric layer, and a second conductive layer formed over the oxidized dielectric layer. Specifically, the Examiner cites element 37 in FIGS. 4A-4C as being a dielectric layer. Assuming *arguendo* that this is correct, the "dielectric layer" 37 is formed as a 2-step process wherein in the first step, an organic <u>tantalum charge gas is reacted with an oxygen gas</u>, to thereby form a film which coats the entire structure, and then in the second step, the film is further processed by a **<u>plasma chemical reaction</u>** using tantalum halogenide charge gas and nitrous oxide gas. The result of this 2-step process is the "capacitive insulating film 37" (col. 5, lns. 33-40). Kamiyama does not disclose any oxidation of the capacitive insulating film/ "dielectric" 37.

Also, Kamiyama fails to teach or suggest processing any layer with hydrogen gas, much less with a combination of hydrogen gas, oxygen gas and nitrous oxide gas for the purpose of oxidizing such layer. Needless to say, Kamiyama also does not recognize the synergistic effect of oxidizing a dielectric layer of a capacitor with a combination of hydrogen gas, oxygen gas and nitrous oxide gas, or provide any other motivation to use the claimed combination of gases.

Accordingly, neither of the alternative primary references of Cho and Kamiyama by themselves teach or suggest the claimed invention. The secondary refences to Miner and Schuegraf, even when considered in combination with the primary references, also fail to teach or suggest the claimed invention.

Miner teaches a method of forming an oxide on a nitrogen-containing material by backfilling the reaction chamber with a volume of gas which is a mixture of **two** gases: an oxygen-containing gas and a hydrogen containing gas (col. 8, lns. 13-20, esp. ln. 17). Column 8, lines 20-26 disclose that the hydrogen-containing gas may be H_2, NH_3, deuterium, and hydrocarbons such as methane, and that the oxygen-containing gas can be O_2, or N_2O. Like in Cho and Kamiyama, there is absolutely nothing in the Miner reference to specifically motivate one of ordinary skill in the art to use a combination of hydrogen, oxygen, and nitrous oxide gases to oxidize a dielectric layer of a capacitor.

The last cited reference is Schuegraf, which teaches annealing a dielectric layer in a capacitor in an "oxygen-rich environment" (col. 6, lns. 22-30), wherein the "oxygen-rich environment of the reoxidation anneal step can be obtained using N_2O, O_2, O_3, NO, **or** N_2O gases" (col. 6, lns. 44-46) (emphasis added). There is no disclosure of using hydrogen gas, and again, no motivation for combining hydrogen, oxygen, and nitrous oxide gases to oxidize a dielectric capacitor layer.

It is a well-recognized principal in patent law that "[v]irtually all inventions are necessarily combinations of old elements." Panduit Corp. v. Dennison Mfg. Co., 810 F.2d 1561, 1 U.S.P.Q.2d 1593, 1603 (Fed. Cir.) *cert. den.* 481 U.S. 1052 (1987). However, simply because the various gases disclosed in the cited prior art references can be combined, any conclusion that such modification and/or combination of the prior art references is inappropriate, unless the references provide motivation for the specifically claimed combination of elements. *See, e.g.*, In re Mills, 916 F.2d 680, 682, 16 U.S.P.Q.2d 1430, 1432 (Fed. Cir. 1990); In re Bond, 910 F.2d 831, 834, 15 U.S.P.Q.2d 1566, 1568 (Fed. Cir. 1990). For example, in In re Rouffet, the Federal Circuit overturned an obviousness rejection on the basis that although all the elements of the claimed invention were taught in the cited references, there was no motivation provided in the references to modify the prior art to arrive at the claimed invention. 149 F.3d 1350, 47 U.S.P.Q.2d 1453 (1998).

Since none of Cho, Kamiyama, Miner or Schuegraf teaches or demonstrates any specific motivation to use a combination of hydrogen, oxygen and nitrous oxide gases to form an oxidation layer on a dielectric layer, Applicants respectfully submit that the subject matter of claims 1 and 40 in the present application is not rendered obvious by the teachings of these references.

2. <u>The Thickness of the Dielectric Layer as Recited in Claims 2-4, 35-38, 43-44 and 56 Is Not Taught or Suggested by the References</u>.

Tables 1 and 2 on pages 12-13 in Appellants' specification provides results for dielectric layers of 59 Angstroms and 47 Angstroms in each of Groups 1-4. As can be seen from these Tables, the reduction in leakage current in Groups 2-4 over the samples of Group 1 is significant for the 59 Angstrom thick dielectric layers (about 15%), and even more dramatic for the 47 Angstrom thick dielectric layers (about 60%). Dependent claims 2 and 43 each recites that the dielectric layer does not exceed 60 Angstroms in thickness. Similarly, dependent claims 3 and 44 recite that the dielectric layer does not exceed 50 Angstroms in thickness, while dependent claims 4 and 56 recite that the dielectric layer has a thickness between 45 and 50 Angstroms, and dependent claims 35-37 all specifically recite that the dielectric layer is 47 Angstroms thick.

Although the final rejection fails to discuss the inventive features recited in chaims 2-4, 35-38, 43, 44 and 56, Appellants note that Cho discloses a dielectric layer having a thickness of 400 Angstroms, and Schuegraf discloses a dielectric layer of 40-100 Angstroms (Schuegraf, col. 6, lns. 19-21). Kamiyama and Miner are silent as to any thicknesses of any dielectric layer in a semiconductor capacitor. Schuegraf's disclosed range, however, is very broad, and does not recognize the significantly superior results achieved with the claimed thicknesses, especially in the 45-50 Angstrom range, and especially in combination with the inventive features recited in independent claims 1 and 40 (and any other claims from which claims 2, 3, 4, 35, 36, 37, 43, 44 and 56 respectively

depend). As such, in addition to being patentable over the cited references for the reasons attributable to independent claims 1 and 40 as discussed above, these claims are also separately patentable on the basis of the further inventive feature respectively recited in each of these claims.

3. The Thickness of the Oxide Layer as Recited in Claims 13-14, 39 and 57-58 Is Not Taught or Suggested in the References.

Dependent claims 13, 39 and 57 each recite that the oxidation layer formed on the dielectric layer is formed to a thickness which is less than about 5 Angstroms, and dependent claims 14 and 58 recite that the oxidation layer is formed to a thickness which is less than about 3 Angstroms.

The final rejection again makes no mention of these claimed features. The only disclosure in any of the cited references to any thicknesses of oxidation layers is found in Schuegraf, column 6, lines 59-67. Specifically, Schuegraf teaches that the oxide layer 68 formed on the dielectric layer 64 is formed to a thickness of between 5 and 15 Angstroms. Since there is no teaching or suggestion in the cited references of the inventive features recited in claims 13, 14, 39, 57 and 58, these claims are each distinctly patentable based on the subject matter recited in these claims, in addition to the gas mixture subject matter recited in their respective base claims.

4. The References Provide No Teaching or Suggestion of the Flow Rates of Each of the Gases as Recited in Claims 6-8, 15-34, 45-47, 49, 51-55 and 59.

Dependent claims 6-8, 15-29, 30-34, 45-47, 49, 51-55 and 59 are each directed to the flow rates for gases recited in independent claims 1 and 40. Specifically, claims 6-8, 15-16, 18-20, 25-34, 45-46, 51-55 and 59 all recite specific flow rates (in standard liters per

minute) or a flow rate range for at least one of the oxygen, hydrogen and nitrous oxide gases. Claims 6, 27, 30 and 52 recite that the flow rate for nitrous oxide gas is at least about 2.5 standard liters per minute (slm), whereas claims 7, 28, 31 and 53 recite that the flow rate for nitrous oxide gas is at least about 5 slm, and claims 8, 29, 32 and 54 recite that the flow rate for nitrous oxide gas is at least about 10 slm.

As discussed on page 8, line 21 through page 9, line 1, leakage current is reduced as the flow rate of nitrous oxide is increased. This effect is most clearly demonstrated in experimental results for the samples having the 47 Angstrom thick dielectric layers, as set forth in Tables 1 and 2 of the specification. Specifically, in the samples having the 47 Angstrom thick dielectric layer of Group 2, the nitrous oxide flow rate was 2.5 slm, and the leakage current obtained was 46% the leakage current obtained in the samples of Group 1 when nitrous oxide was not used to oxidize the dielectric layer. In the samples of Group 3, the flow rate of nitrous oxide was 5 slm, and the leakage current obtained was 42% that obtained for the samples of Group 1. In the samples of Group 4, the flow rate of nitrous oxide was 10 slm, and the leakage current obtained was 37% of the leakage current obtained for the samples of Group 1.

In addition to the defects demonstrated above, the final rejection also does not demonstrate that any of the claimed flow rates are taught or suggested in the prior art. In particular, the cited references do not disclose any correlation between flow rate of nitrous oxide gas during oxidation of the dielectric layer and the leakage current obtained in the resulting capacitor. Moreover, a careful review of each of Cho, Kamiyama, Miner or Schuegraf reveals that none of these references discloses or suggests any of the claimed flow rates for any of the gases. Cho, Kamiyama and Schuegraf are silent as to flow rates entirely, while Miner merely teaches a volume ratio of H_2 gas to O_2 gas (col. 10, lns. 55-56), but does not teach or suggest any of the (specific, ranges or relative) flow rates recited in claims 6-8, 15-16, 18-22, 25-34, 45-47, 49, 51-55 and 59. Thus, these claims are also patentable both on the merits of the features respectively recited therein, and also by virtue of being ultimately dependent from either claim 1 or 40.

5. <u>The References Provide No Teaching or Suggestion of the Ratio of the Gases as Recited in claims 5 and 48</u>.

Dependent claims 5 and 48 each recite that the ratio of nitrous oxide gas to oxygen gas and to hydrogen gas, respectively, is in the range of from about 0.05 to about 1.7.

While the final rejection is silent as to the merits of claims 5 and 48, Appellants note that only Miner discloses a ratio of gases used for oxidation. Specifically, column 8, line 57 through column 9, line 17 in Miner discloses H_2/O_2 ratios of 2:1, 0.5:1, and various percentages. None of the ratios disclosed in Miner compare an amount of nitrous oxide gas to either oxygen gas or nitrogen gas, as recited in Appellants' claims. Accordingly, claims 5 and 48 are patentable on their own merits, in addition to the reasons attributable to independent claims 1 and 40.

B. THE SUBJECT MATTER DISCLOSED IN THE CITED REFERENCES CANNOT BE COMPATIBLY COMBINED OR MODIFIED.

Cho, Kamiyama, Miner, and Schuegraf disclose vastly different processes which cannot be combined. Cho uses a plasma to treat the surface of a dielectric layer. In other words, Cho's dielectric layer is never contacted with a hydrogen gas, an oxygen gas, and a nitrous oxide gas, as claimed in the present application.

Miner teaches reoxidizing a nitride-containing substrate by a two-component gas mixture, *i.e.*, an oxygen-containing gas and a hydrogen-containing gas. The two gases are reacted together to in a chamber to form moisture or steam (Miner, col. 5, lines 15-18). Column 5, lines 32-37 discloses that "a rapid thermal steam process utilizing in situ steam generation is ideally suited for reoxidizing a silcon film or substrate in the presence of a nitrogen containing material or nitride film.

Schuegraf teaches a high-pressure, oxygen–rich annealing process for oxidizing a capacitor dielectric layer.

Kamiyama does not even oxidize a dielectric layer. Instead, Kamiyama forms an oxide tantalum film by reacting two gases together, *i.e.*, an organic tantalum charge gas and oxygen charge gas. The reaction of these two gases forms a film which settles on the surface of the structure placed in the reaction chamber.

Since Cho, Miner, Schuegraf and Kamiyama disclose vastly different processes using different types of reactions performed under different conditions and using different states of matter, there is no reason why one of ordinary skill in the art would look to combine any of these references together to arrive at Appellants' claimed invention. Moreover, there is absolutely nothing in any of these references which would lead one of ordinary skilled in the art to realize the significant, unexpected results obtained by oxidizing a dielectric layer with the specific combination of hydrogen, oxygen, and nitrous oxide gases.

IX. CONCLUSION

Cho, Kamiyama, Miner, and Schuegraf, whether considered alone or in any combination, fail to render obvious Appellants' claimed invention, since the combined teachings do not suggest oxidizing a dielectric layer of a semiconductor capacitor with hydrogen gas, oxygen gas, and nitrous oxide gas, or the resulting capacitor having a greatly reduced leakage current. For each of the foregoing reasons, Appellants respectfully submit that the claimed invention is novel and non-obvious over the cited prior art, and reversal of the final grounds of rejection is respectfully solicited.

X. CLAIMS INVOLVED IN THE APPEAL

A copy of the claims involved in the present appeal is attached hereto as Appendix A.

Dated: October 7, 2002

Respectfully submitted,

By____________________________

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